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(54) **ADAPTIVE HIGH DYNAMIC RANGE CAMERA**

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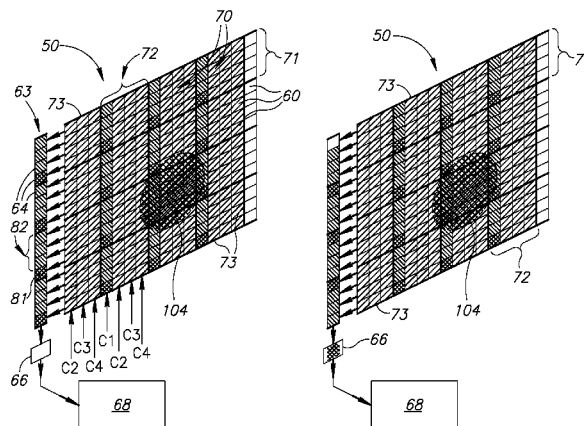*Assistant Examiner* — Frank Huang
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(57)   **ABSTRACT**

An embodiment of the invention provides a time of flight 3D camera comprising a photosensor having a plurality of pixels that generate and accumulate photoelectrons responsive to incident light, which photosensor is tiled into a plurality of super pixels, each partitioned into a plurality of pixel groups and a controller that provides a measure of an amount of light incident on a super pixel responsive to quantities of photoelectrons from pixel groups in the super pixel that do not saturate a readout pixel comprised in the photosensor.

15 Claims, 4 Drawing Sheets

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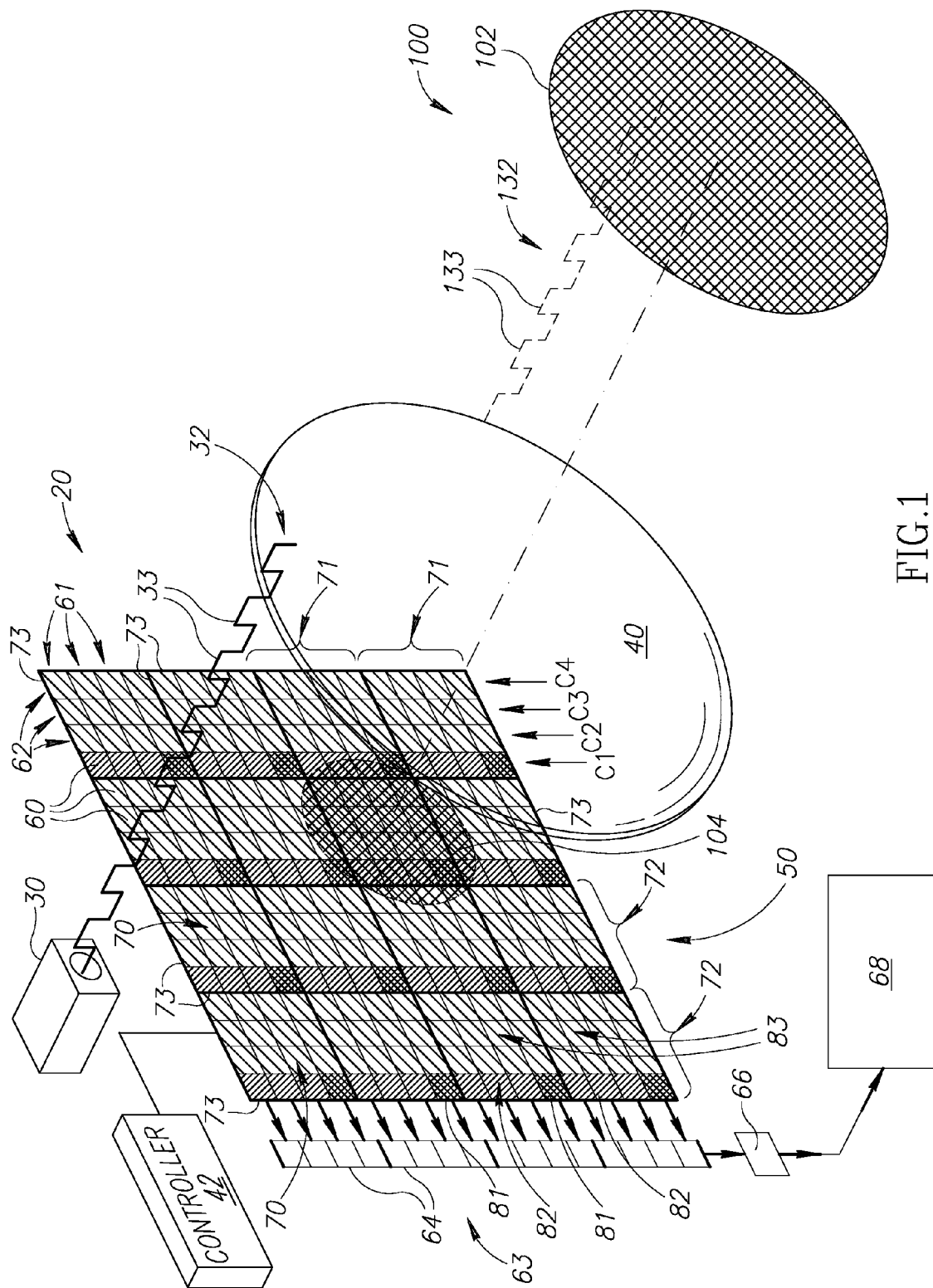
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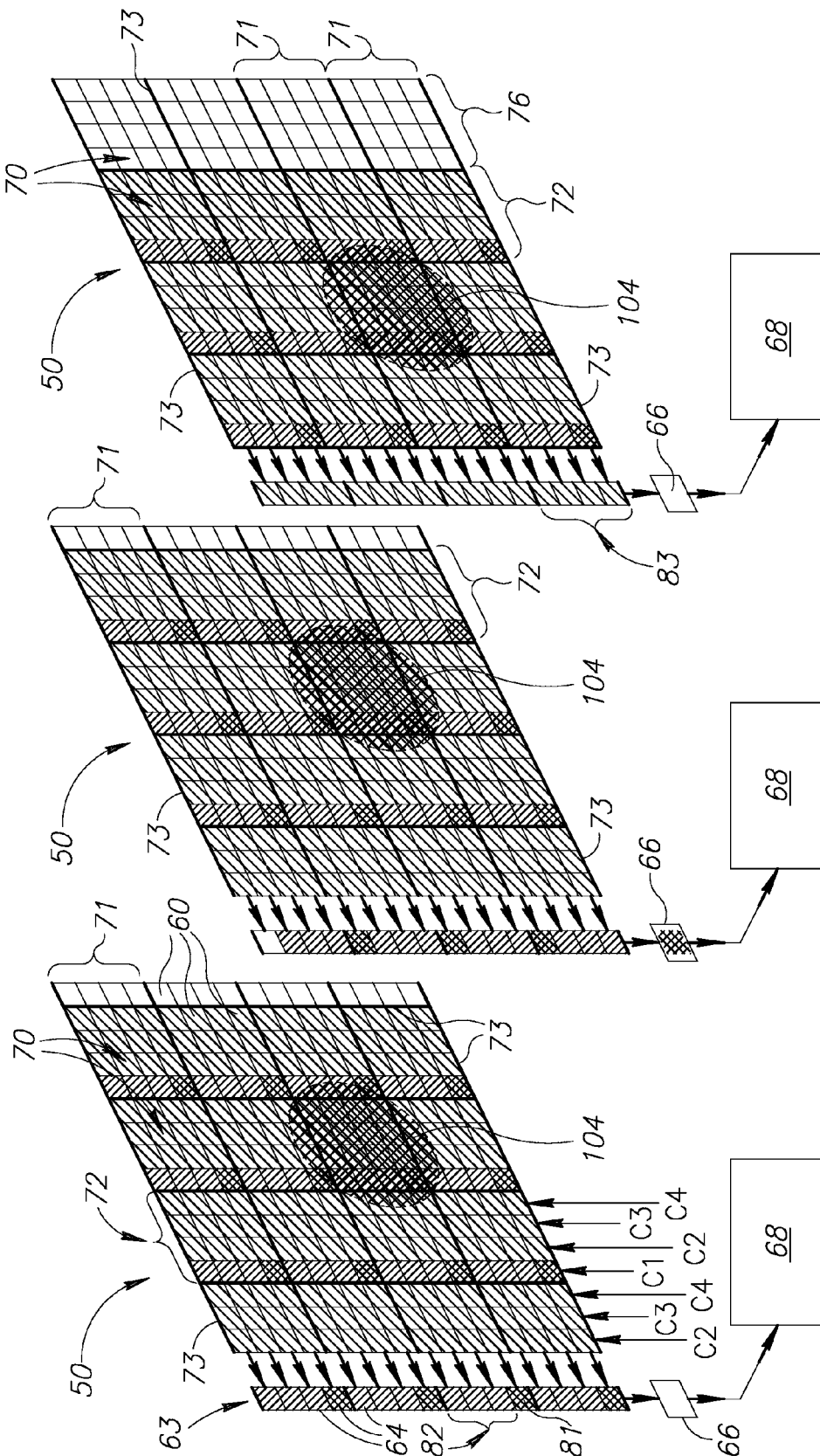
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FIG.1

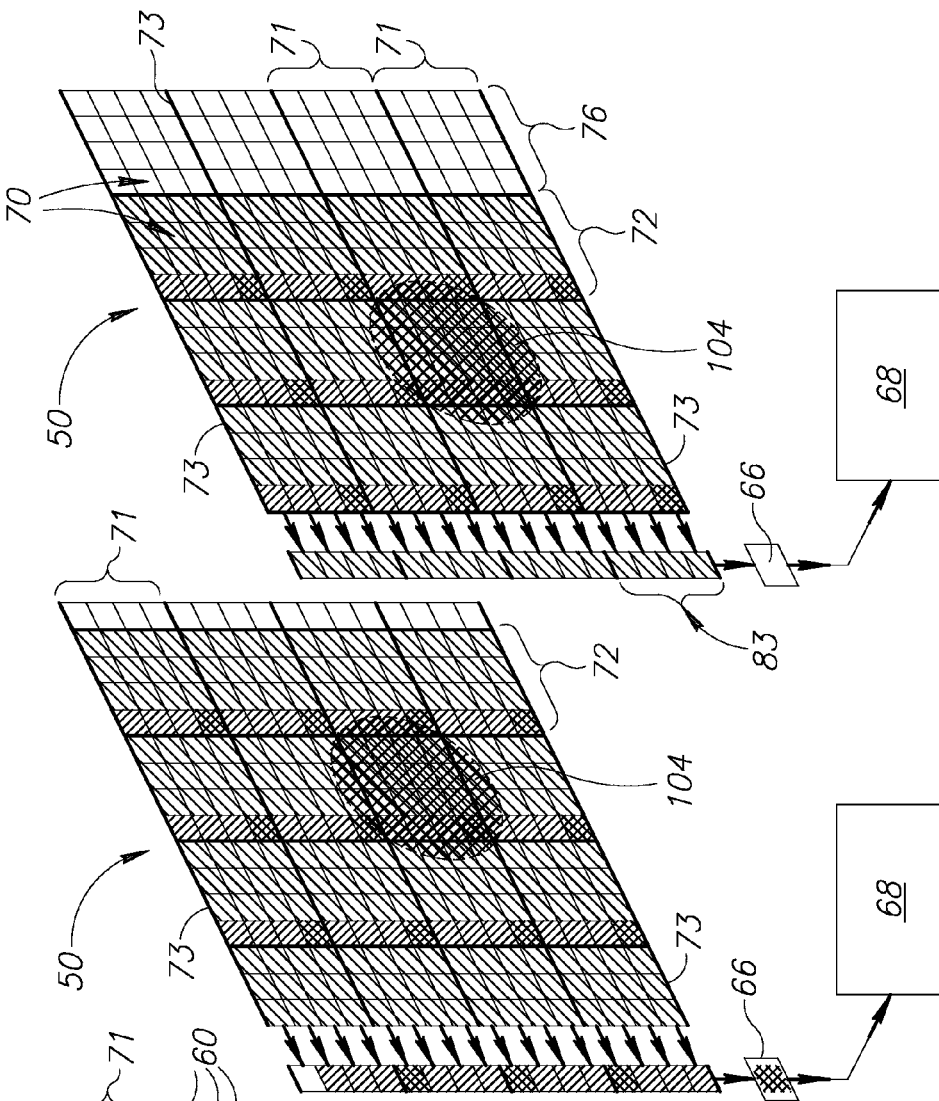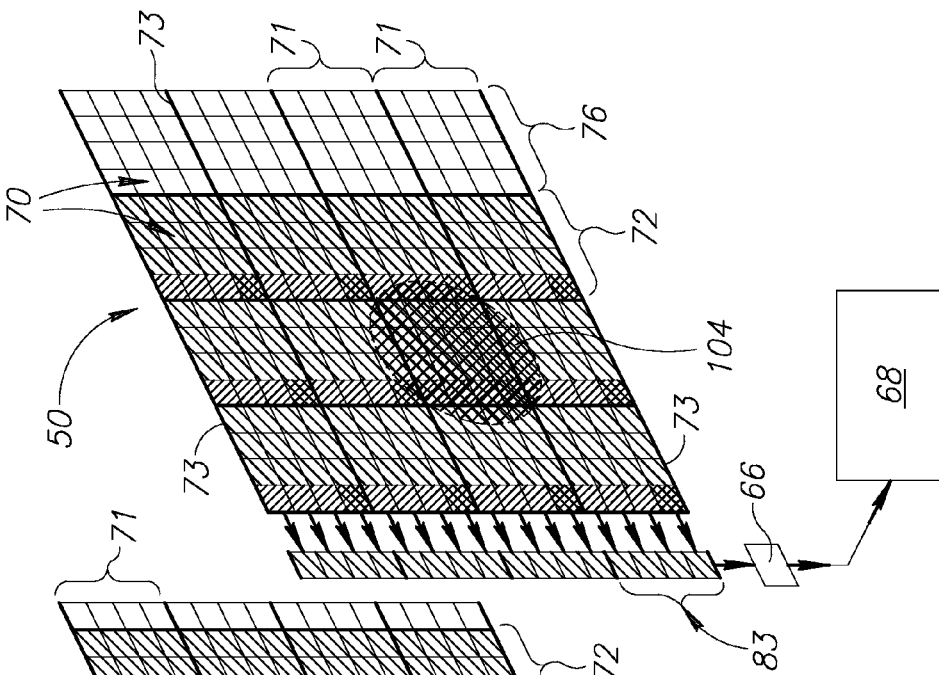FIG.2A

FIG.2B

FIG.2C

200

202

$V81 \approx Vs$?

YES

204

SPe
UNDETERMINABLE

NO

206

$V82 \approx Vs$?

YES

208

SPe=
16V81e

NO

210

$V83 \approx Vs$?

YES

212

SPe=
4(V81e+V82e)

NO

214

SPe=
V81e+V82e+V83e

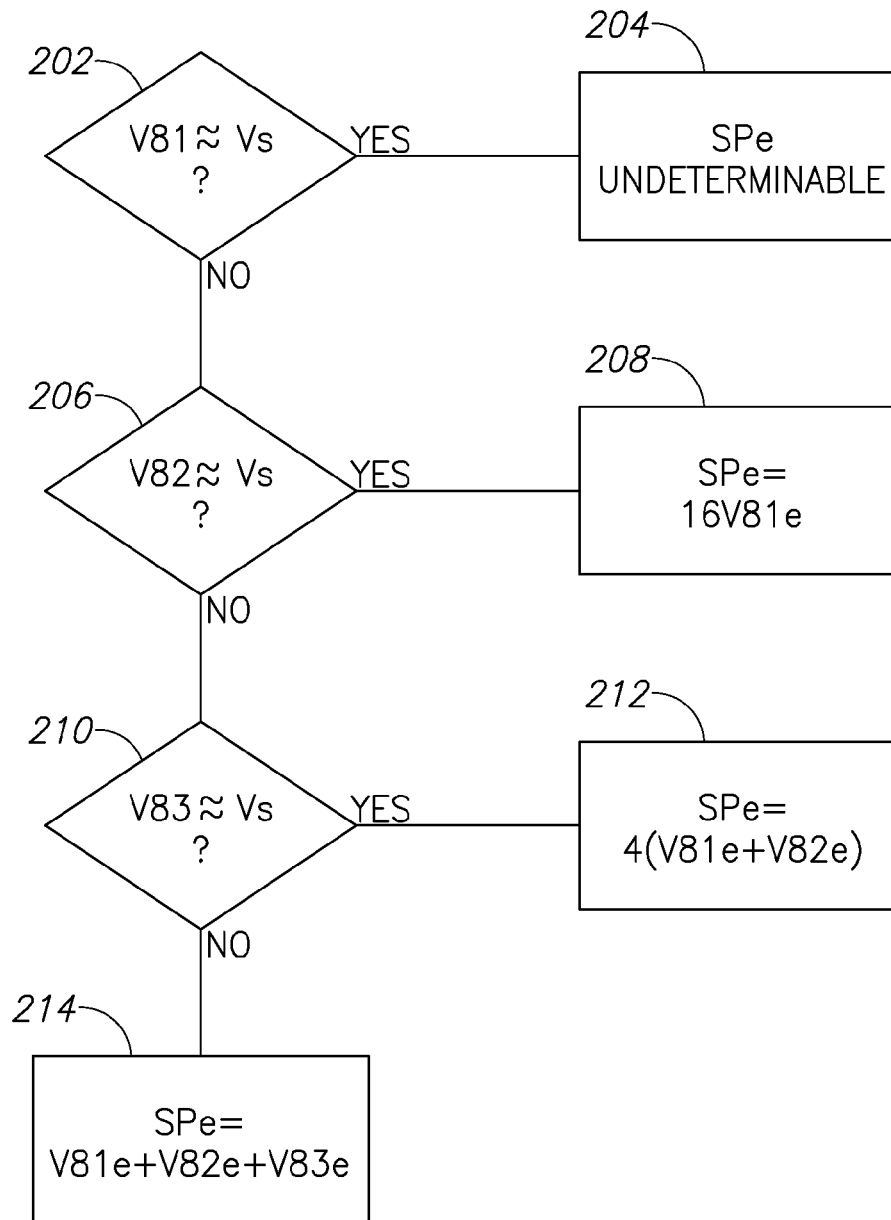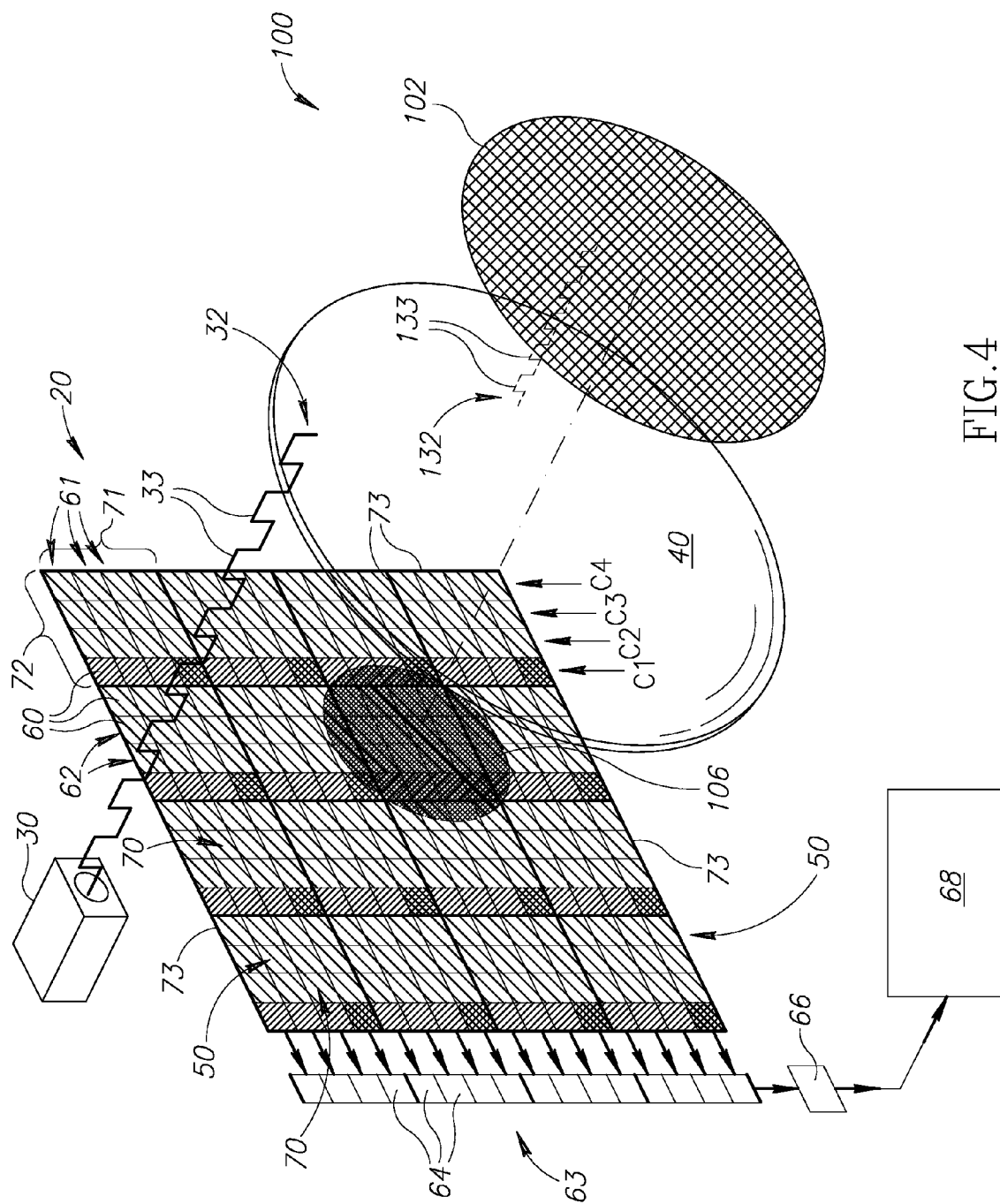FIG.3

FIG.4

ADAPTIVE HIGH DYNAMIC RANGE CAMERA

TECHNICAL FIELD

Embodiments of the invention relate to adjusting sensitivity of a camera to light that it receives from a scene that the camera images.

BACKGROUND

Time of flight (TOF) three-dimensional (3D) cameras determine distances to features in a scene by acquiring an image, conventionally referred to as a "range image", of the scene that can be processed to determine how long it takes light to travel from the camera to the features and back to the camera. The round trip flight times of the light to, and back from the features, and the speed of light are used to determine the distances to the imaged features.

In a gated TOF-3D camera, light pulses are transmitted to illuminate a scene and the camera is shuttered on, "gated on", following each light pulse for a relatively short exposure period to enable pixels in a photosensor of the camera to receive and register light from the light pulses reflected by features in the scene that reaches the camera. A pixel in the photosensor registers an amount of incident light it receives by generating, and accumulating, a quantity of electrons, hereinafter "photoelectrons", in the pixel that is substantially proportional to the amount of incident light. The accumulated photoelectrons are transmitted to a readout pixel comprised in the photosensor. A readout circuit converts a charge provided by the photoelectrons transferred to the readout pixel to a voltage, hereinafter also "photo-voltage", which provides a measure of the charge, and thereby the number of photoelectrons and the corresponding amount of incident light. A process of converting photoelectrons in a pixel to a photo-voltage is referred to as "reading" the pixel.

In order to provide reliable measurements of amount of light, photosensors are typically provided with a readout pixel that can accumulate a number of photoelectrons before it saturates that is equal to about twice a number of photoelectrons that saturates a pixel of the photosensor. A pixel saturates when a number of photoelectrons generated or received by the pixel is greater than the pixel's capacity to store photoelectrons. Photoelectrons in excess of a saturation threshold drain off to ground and cannot contribute to measurements of light.

Determination of a quantity of photoelectrons accumulated in a pixel by reading the pixel is subject to error from shot noise and read noise. Shot noise is a statistical error that is a function of the number of photoelectrons accumulated. If Ne is the number of photoelectrons, shot noise may be estimated to result in a fractional error (fractional error is % error multiplied by 100) in Ne equal to about $1/\sqrt{Ne}$. Read noise is independent of the number of photoelectrons. Read noise is a "device" noise that is introduced into a determination of a number of photoelectrons by the process of determining the number. If read noise is represented by a constant RE a fractional error in Ne may be estimated to be equal to about RE/Ne.

Distance to a feature in the scene imaged on a pixel of the camera photosurface is determined as a function of photo-voltage representing an amount of light that reaches the pixel from the feature during the short exposure periods, normalized to a photo-voltage representing a total amount of light reflected from the pulses that reaches the pixel from the feature. For convenience, light registered during the short

exposure periods of the camera is referred to as "gated" light. An amount of light used to normalize gated light to determine distance is received during exposure periods that are substantially longer than the short exposure periods used to provide gated light, and is referred to as "ungated light".

Typically, widths of the light pulses and the short exposure periods are very small, and may for example be less than or about equal to 20 nsec (nanoseconds). As a result, amounts of gated light registered by pixels in a gated TOF-3D camera are often relatively small, and errors in measurements of gated light, and consequently in distance measurements provided by the TOF-3D camera due to shot and read noise can be relatively large. For features of a scene that have low reflectivity and/or are relatively far from the camera, amounts of light from the features registered by pixels on which the features are imaged can be so small that shot noise error in measurements of the light generates unacceptably large errors in distance measurements to the features. If camera parameters and/or lighting are adjusted to compensate for low reflectivity and/or for relatively large distances of features in the scene, near and/or high reflectivity features in the scene may be poorly imaged because light from these features saturates pixels in the camera.

As a result, for many applications of a TOF-3D camera, the camera does not have a dynamic range (DNR) for measuring incident light sufficiently large to acquire range images that provide acceptable distance measurements for both "dim" and "bright" features in a scene. A camera DNR is typically measured as a ratio between a maximum amount of light per unit area of the camera photosensor, which the camera measures with an acceptable precision, divided by a minimum amount of light per unit area of the photosensor, which the camera measures with an acceptable precision.

Light incident on a surface per second per unit area of the surface is referred to as irradiance. A maximum amount of light incident per unit area of a photosensor that a camera measures with an acceptable precision may therefore be referred to as a maximum integrated irradiance, (MaxIr). Similarly, a minimum amount of light incident per unit area of a photosensor that a camera measures with an acceptable precision may be referred to as a minimum integrated irradiance, (MinIr). A camera DNR may conveniently be defined by an expression DNR=MaxIr/MinIr.

SUMMARY

Aspects of an embodiment of the invention relate to providing a camera characterized by an improved DNR for acquiring an image of a scene responsive to light that the camera receives from the scene.

In an embodiment of the invention the camera comprises a photosensor having light sensitive pixels tiled into super pixels onto which the received light is imaged. Tiling a photosensor refers to subdividing the photosensor into areas that group pixels in the photosurface for convenient or advantageous reading. Tiling is generally implemented by programming

Each super pixel into which the photosensor is tiled is partitioned into a plurality of non overlapping groups of pixels, which pixel groups together include all the pixels in the super pixel. Optionally, each pixel group in a same super pixel includes a different number of pixels. A controller transfers photoelectrons generated by light from the scene and accumulated in each pixel group to a readout pixel, and determines if a photo-voltage generated responsive to a quantity of the photoelectrons transferred from the pixel group to the readout pixel indicates that the quantity saturates the readout pixel.

The controller provides an estimate of an amount of light incident on the super pixel responsive to photo-voltage generated from quantities of photoelectrons from pixel groups in the super pixel that do not appear to saturate the readout pixel.

As a result of processing photoelectrons generated and accumulated in pixels of a super pixel in accordance with an embodiment of the invention, for a same given percent accuracy of measurement, a super pixel comprising N pixels of the photosensor has a MinIr that is equal to about 1/N times that of a single pixel in the photosensor. The super pixel also has a MaxIr substantially equal to a MaxIr of the single pixel. A camera, that configures its photosensor to have super pixels and determines intensities of light registered by the super pixels in accordance with an embodiment of the invention therefore has a DNR that is about N times that of a camera, hereinafter also a "conventional camera", which operates its photosensor without super pixels.

In an embodiment of the invention, the camera photo sensor is tiled to square, 4×4 super pixels, each comprising 16 pixels of the photosensor, and each partitioned into three pixel groups comprising respectively 1, 3, and 12 pixels. Each super pixel registers about 16 times an amount of light registered by a single pixel and when processed in accordance with an embodiment of the invention has a DNR that is about 16 times that of a conventional camera. Tiling a photosensor to 4×4 super pixels is referred to as operating the photosensor in a quarter-quarter video graphic array (QQVGA) mode. In some embodiments of the invention a camera comprises a photosensor tiled into square 2×2 super pixels and may be referred to as operating in a quarter video graphics array (QVGA) mode.

This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter.

BRIEF DESCRIPTION OF FIGURES

Non-limiting examples of embodiments of the invention are described below with reference to figures attached hereto that are listed following this paragraph. Identical structures, elements or parts that appear in more than one figure are generally labeled with a same numeral in all the figures in which they appear. Dimensions of components and features shown in the figures are chosen for convenience and clarity of presentation and are not necessarily shown to scale.

FIG. 1 schematically shows a TOF-3D camera comprising a photosensor comprising QQVGA super pixels acquiring an image of a scene having an object at a relatively large distance from the camera, in accordance with an embodiment of the invention;

FIGS. 2A-2C schematically show a process for reading super pixels, in accordance with an embodiment of the invention;

FIG. 3 shows a flow diagram of an algorithm that the TOF-3D camera shown in FIG. 1 executes to determine intensities of light registered by super pixels in accordance with an embodiment of the invention; and

FIG. 4 schematically shows the TOF-3D camera shown in FIG. 1 acquiring an image of a scene having an object at a relatively small distance from the camera, in accordance with an embodiment of the invention.

DETAILED DESCRIPTION

In the following paragraphs of the detailed description, operation of a TOF-3D camera operating in a QQVGA mode

for which the camera's photosensor is tiled into 4×4 super pixels, in accordance with an embodiment of the invention is discussed with reference to FIG. 1. In FIG. 1 the camera is schematically shown operating to acquire a range image of a scene comprising an object located relatively far from the camera, as a result of which an amount of light collected by the camera from the object and imaged on pixels of the camera's photosensor is relatively small. A procedure by which the TOF-3D camera reads super pixels in accordance with an embodiment of the invention is discussed with reference to FIGS. 2A-2C. An algorithm by which the TOF-3D camera determines quantities of photoelectrons accumulated by super pixels in the camera is discussed with reference to a flow diagram shown in FIG. 3. Aspects of imaging objects close to the TOF-3D camera are discussed with reference to FIG. 4 which shows the object in FIG. 1 moved so that it is relatively close to the camera. MinIr and MaxIr are discussed with reference to the figures and a DNR for a camera in accordance with an embodiment of the invention is provided.

FIG. 1 schematically shows a TOF-3D camera 20 imaging a scene 100 comprising an object 102 schematically represented by a shaded circle to acquire an image of the scene responsive to gated light and determine distances to regions of the object, in accordance with an embodiment of the invention. In FIG. 1 the object is assumed by way of example to be relatively far from the camera and to be characterized by moderate to low reflectivity.

TOF-3D camera 20 comprises a light source 30 controllable to radiate a train of relatively short light pulses schematically represented by a train 32 of pulses 33 to illuminate scene 100, a photosensor 50, and an optical system represented by a lens 40. Optical system 40 collects light that is reflected from light pulses 33 back to the camera by object 102 and images the collected light onto the photosensor. The optical system also comprises a shutter (not shown) for shuttering the camera open for relatively short exposure periods to acquire an image of scene 100 responsive to gated light, and optionally for relatively long exposure periods to acquire an image of the scene responsive to ungated light. A controller 42 controls the camera components.

Photosensor 50 comprises rows 61 and columns 62 of light sensitive pixels 60, a transfer column 63 of transfer pixels 64, a readout pixel 66 and readout circuitry 68 that converts charge provided by photoelectrons accumulated in the readout pixel to photo-voltage. In accordance with an embodiment of the invention photosensor 50 is tiled into rows 71 and columns 72 of super pixels 70. The super pixels are outlined by bold lines 73. By way of example, TOF camera 20 is assumed to be operating in a QQVGA mode and each super pixel is a square 4×4 super pixel comprising sixteen pixels 60. Each super pixel 70 is optionally divided into three pixel groups 81, 82 and 83 comprising respectively 1, 3 and 12 pixels 60. The different pixels groups are shaded differently to distinguish them. Optionally, pixel groups 81, 82 and 83 in different super pixels 70 are homologous.

Let columns 62 of pixels 60 in a same column 72 of super pixels 70 be referred to, left to right in FIG. 1, as columns C1, C2, C3 and C4. Optionally, pixels 60 in pixel groups 81 and 82 in a same column of super pixels 70 are located in column C1 as shown in FIG. 1. Optionally, pixels 60 in pixel groups 83 in a same column 72 of super pixels 70 are located in columns C2, C3, and C4 in the column of super pixels. For convenience of presentation in FIG. 1 and figures that follow, photosensor 50 is shown comprising only 4 rows and 4 columns of super pixels 70. Embodiments of the invention are of course not limited to four rows or four columns of pixels, and

in practice a photosensor will in general comprise many hundreds of rows and columns of super pixels.

To acquire a range image of scene **100** and determine distances to regions of object **102** controller **42** controls camera **20** to image scene **100** responsive to gated light and an image of scene **100** responsive to ungated light. A distance to a region of object **102** imaged on a super pixel **70** is determined responsive to an amount of gated light registered by the super pixel normalized to an amount of ungated light registered by the pixel.

To image scene **100** responsive to gated light, controller **42** controls the shutter to shutter camera **20** open for a short exposure period following each pulse **33** during which exposure period pixels **60** in photosensor **50** register light reflected from the light pulses that reaches the camera and is imaged on the photosensor. Light reflected from light pulses **33** and imaged by optical system **40** on photosensor **50** is schematically represented by a train **132** of reflected light pulses **133** shown in dashed lines. An image of a region of object **102** imaged on a super pixel **70** responsive to reflected light pulses **133** registered by pixels **60** during the short exposure periods is schematically represented by a shaded circle **104** on the photosensor.

Following a last pulse **33** radiated by light source **30** to illuminate scene **100**, the photosurface is "read" to determine a total amount of light, in the present example gated light, registered by each super pixel **70** during the short exposure periods following light pulses **33**.

In accordance with an embodiment of the invention, photosensor **50** is read by reading super pixels in a first column **72** of super pixels, and then sequentially reading super pixels in the remaining columns **72**. A first column **72** of super pixels **70** is on the left hand edge of photosensor **50**.

To read super pixels **70** in a column **72** photoelectrons accumulated in pixels **60** of column C1 of the super pixel column are shifted into corresponding shift pixels **64** in shift column **63** by shifting the photoelectrons in all columns **62** of photosensor **50** one column **62** "left" toward the shift column (one column to the left in FIG. **1**). FIG. **2A** schematically shows photosensor **50** after photoelectrons from column C1 of the first column **72** of super pixels **70**, are shifted into shift pixels **64** of shift column **63**. Pixels in the figure that have no shading are pixels that have been emptied of photopixels in the process of shifting photoelectrons to shift column **63**. Photoelectrons in shift pixels **64** are then shifted "down" to sequentially shift photoelectrons in pixel groups **81** and **82** in the shift column into readout pixel **66**. FIG. **2B** schematically shows photosensor **50** after photoelectrons in shift pixels **64** of shift column **63** have been shifted down by one shift pixel **64** to move electrons in a first (bottom in the figure) shift pixel **64** containing photoelectrons in a first group **81**, into readout pixel **66**.

After photoelectrons in a group **81** or **82** are shifted into readout pixel **66**, readout circuit **68** converts the electric charge provided by the photoelectrons to a photo-voltage, thereby emptying the readout pixel and preparing it to receive photoelectrons from a next pixel group. Controller **42** stores the photo-voltage generated by readout circuit **68** for each pixel group for use later as discussed below.

Following reading of pixel groups **81** and **82** in column C1 of the super pixel column **70**, controller **42** controls photosensor **50** to shift photoelectrons accumulated in pixel groups **83** into shift pixels **64** of shift column **63** by shifting photoelectrons in all columns **62** of pixels **60** three columns **62** left, towards the shift column. FIG. **2C** schematically shows photosensor **50** after it has been controlled to shift the photoelectrons from pixel groups **83** in the first column **72** of super

pixels **70** into shift column **63**. After photoelectrons from pixel groups **83** from the first column of super pixels has been shifted into shift pixels **64**, controller **42** controls the shift column to sequentially shift the photoelectrons from each pixel group down into readout pixel **66**. Readout circuit **68** generates a photo-voltage for the photoelectrons from each pixel group **83**, which controller **42** optionally stores.

In accordance with an embodiment of the invention, controller **42** then uses the stored photo-voltages to determine a number of photoelectrons accumulated by each super pixel in column **70** in accordance with a flow diagram **200** of an algorithm shown in FIG. **3**. Numeral **200** is also used to refer to the algorithm.

Let the photo-voltages determined for pixel groups **81**, **82** and **83** for a given super pixel be represented by V**81**, V**82**, and V**83** respectively. Let a number of photoelectrons accumulated by pixel groups **81**, **82**, and **83**, corresponding to photo-voltages V**81**, V**82**, and V**83** be represented by V**81**e, V**82**e, and V**83**e. Let a number of photoelectrons in a super pixel comprising the pixel groups be represented by SPe. It is noted that for a same light intensity incident on all pixel groups of the given super pixel, it is expected that V**83**=12V**81** and that V**82**=3V**81**.

In a decision block **202** of algorithm **200**, controller **42** checks to decide if V**81** indicates that a number V**81**e of photoelectrons in response to which V**81** was generated, indicates that the number V**81**e saturated readout pixel **66**. In an embodiment of the invention, a photo-voltage generated by readout circuit **68** responsive to charge provided by photoelectrons in readout pixel **66** is assumed to saturate the readout pixel if it is about equal to a photo-voltage, V_S, which is generated when the readout pixel is filled to capacity with photoelectrons. If V**81** is equal to about V_S, in symbols V**81**≈V_S, the controller proceeds to a block **204**. In block **204** the controller determines that that the super pixel is saturated and that a quantity, SPe, of photoelectrons accumulated by the super pixel cannot reliably be determined.

If on the other hand V**81** does not saturate readout pixel **66**, controller **42** proceeds to a decision block **206** to decide whether photo-voltage V**82**≈V_S and therefore that photoelectrons transferred to readout pixel **66** saturated the readout pixel. If V**82**≈V_S controller **42** proceeds to a block **208** and determines that a number of photoelectrons, SPe, accumulated by the super pixel during the short gates is about 16 times V**81**e, that is, SPe=16(V**81**e). If on the other hand, V**82**<V_S, controller **42** proceeds to a decision block **210** to determine if V**83**≈V_S. If V**83**≈V_S controller **42** proceeds to a block **212** and determines that SPe=4(V**81**e+V**82**e). If on the other hand V**83**<V_S, then the controller proceeds to a block **214** and determines that SPe=(V**81**e+V**82**e+V**83**e).

Under the stated assumptions that object **102** is relatively far from camera **20** and not characterized by a particularly high reflectivity, it is expected that each pixel **60** on which image **104** (FIGS. **2A**-**2C**) of object **102** is formed accumulates a relatively small number of photoelectrons. As a result, determinations of quantities of photoelectrons in the pixels will be subject to relatively large shot noise and read noise, and distances to regions of object **102** using the determinations will be characterized by relatively large error margins. On the other hand, because of the relatively small quantities of photoelectrons stored in pixels **60**, it is expected that none of the pixel groups **81**, **82** and **83** in the various super pixels **70** on which image **104** is formed saturates readout pixel **66**, and that therefore SPe for the super pixels will be equal to (V**81**e+V**82**e+V**83**e).

The sum (V**81**e+V**82**e+V**83**e) is relatively large compared to a number of photoelectrons accumulated in a single pixel

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60. As a result, a distance measurement based on a number of photoelectrons accumulated by a super pixel 70 in accordance with an embodiment of the invention is substantially more accurate than a distance measurement based on single pixel 60.

For example, for the QQVGA operation of camera 20, it is reasonable to assume that a number of photoelectrons, SPe, determined for a super pixel 70 will, on the average, be about 16 times larger than a number of photoelectrons accumulated in a single pixel 60. A fractional error in SPe due to shot noise will therefore be about ¼ that of a determination of a number of photoelectrons in a single pixel 60. A fractional error in SPe due to read noise will be about ⅛ that of a fractional read noise error in a number of photoelectrons in a single pixel 60. As a result, a distance measurement determined from SPe for a super pixel in accordance with an embodiment of the invention, will be characterized by a substantially smaller error than a distance determined from a number of photoelectrons accumulated in a pixel 60.

Furthermore, if a minimum number photoelectrons is required to provide a quantity of photoelectrons having an acceptable magnitude of shot noise and read noise, TOF-3D camera 20 can provide the minimum number at an irradiance of its photosensor 50 that is about 16 time smaller than an irradiance required to provide the minimum number from a single pixel 60. As a result, TOF-3D camera 20 in accordance with an embodiment of the invention is characterized by a MinIr that is about 16 times less than a MinIr of a single pixel 60. In general, a camera operating a photosensor having super pixels comprising N pixels, in accordance with an embodiment of the invention, is characterized by an improved MinIr that is 1/N that of the MinIr of a conventional camera.

Whereas for the case of discussed above for which object 102 is located relatively far from camera 20, pixels 60 in general accumulate relatively small numbers of photoelectrons responsive to light pulses 133, the pixels imaging object 102 may accumulate substantially greater numbers of photoelectrons if the object is located relatively close to the camera. Irradiance of photosensor 50 from light pulses 133 increases inversely as the square of the distance of object 102 from camera 20.

For example, if object 102 is located about 3 m (meters) from TOF-3D camera 20 in FIG. 1, and it moves to a distance equal to about 0.5 m from the camera, pixels 60 that image the object at the closer distance will receive about 36 time more light than pixels 60 that imaged the object in FIG. 1. FIG. 4 schematically shows object 102 being imaged by camera 20 at the closer distance. An image 106 of the object formed on photosensor 50 in FIG. 4 is shown shaded substantially darker than image 104 of the object shown in FIG. 1 to indicate the increased irradiance of pixels 60 in image 106 relative to irradiance of pixels 60 in image 104.

For the situation shown in FIG. 4 it is expected that for many super pixels 70 on which object 102 is imaged, quantities of photoelectrons in pixel groups 81, 82, and 83 will saturate readout pixel 66, and not all of the pixel groups will be used to determine a number of photoelectrons for the super pixels. An estimate for a number SPe of photoelectrons in the super pixels will instead be expected to be made in accordance with the expressions SPe=16(V81e) and SPe=4(V81e+V82e) shown in blocks 204 and 208 respectively in the flow diagram for algorithm 200, rather than the expression SPe=(V81e+V82e+V83e) shown in block 214 of the flow diagram.

By determining a quantity of photoelectrons for a super pixel, such as a super pixel 70, in accordance with an embodiment of the invention, responsive to quantities of photoelectrons in pixels groups that do not saturate readout pixel 66,

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super pixels in photosensor 50 are characterized by a MaxIr that is substantially equal to a MaxIr of a single pixel 60. TOF-3D camera 20 therefore has a DNR=MaxIr/MinIr that is about 16 times that of a conventional camera. In general, a camera operating a photosensor having super pixels comprising N pixels in accordance with an embodiment of the invention, has a DNR that is about N times that of a conventional camera.

It is noted that were a photo-voltage generated for a super pixel having N pixels responsive to photoelectrons in a readout pixel only after all the photoelectrons in the pixels of a super pixel were transferred to the readout pixel, the super pixel would have a MaxIr less than that provided by a single pixel. For example, if a quantity of S_e photoelectrons saturates a pixel of the photosensor, and a quantity of SR_e photoelectrons saturates the readout pixel, a MaxIr for the super pixel would be less than about $(SR_e/SP_e)/N$ times a MaxIr for a single pixel. A camera operating such super pixels would have a DNR limited to no more than (SR_e/SP_e) times that of a conventional camera. If, as is common, S_e were equal to about twice a number of photoelectrons that saturates a pixel in the photosurface, then a MaxIr available from the super pixel would be equal to about 2/N that of a single pixel and a camera operating the super pixels would have a DNR not more than twice that of a conventional camera.

Whereas in the above description embodiments of the invention refer to a TOF-3D camera, practice of the invention is not limited to TOF-3D cameras but may be used in any type of camera comprising pixels to increase a DNR of the camera. For example, super pixels and methods of determining amounts of light registered by the super pixels in accordance with an embodiment of the invention, may be used to provide an increased DNR for cameras that provide contrast images, that is pictures, of a scene.

In the description and claims of the present application, each of the verbs, "comprise" "include" and "have", and conjugates thereof, are used to indicate that the object or objects of the verb are not necessarily a complete listing of components, elements or parts of the subject or subjects of the verb.

Descriptions of embodiments of the invention in the present application are provided by way of example and are not intended to limit the scope of the invention. The described embodiments comprise different features, not all of which are required in all embodiments of the invention. Some embodiments utilize only some of the features or possible combinations of the features. Variations of embodiments of the invention that are described, and embodiments of the invention comprising different combinations of features noted in the described embodiments, will occur to persons of the art. The scope of the invention is limited only by the claims.

The invention claimed is:

1. A camera comprising:

a photosensor comprising a plurality of pixels configured to accumulate photoelectrons responsive to incident light, which photosensor is tiled to a plurality of super pixels, each partitioned into a plurality of pixel groups;

a readout pixel configured to receive photoelectrons from the pixel groups;

circuitry that operates to provide a measure of how many photoelectrons are contained in the readout pixel; and

a controller configured to:

transfer photoelectrons accumulated in each pixel group in a super pixel of the plurality of super pixels into the readout pixel to acquire a measure provided by the circuitry of the accumulation of photoelectrons in the pixel group;

determine responsive to the measures which pixel groups have an accumulation of photoelectrons that does not saturate the readout pixel and which pixel groups have an accumulation of photoelectrons that saturates the readout pixel; and

determine a measure of the number of photoelectrons in the super pixel responsive to a function of the measurements of accumulations of photoelectrons in pixel groups of the plurality of pixel groups that do not saturate the readout pixel, which function has a form determined responsive to measurements of the number of photoelectrons in at least two of the pixel groups and is independent of accumulations of photoelectrons in pixel groups that do saturate the readout pixel.

2. The camera according to claim 1 wherein the pixel groups in a super pixel are non-overlapping.

3. The camera according to claim 1 wherein no two pixel groups in a super pixel comprise a same number of pixels.

4. The camera according to claim 3 wherein the controller determines accumulations of photoelectrons for the pixel groups sequentially in increasing order of the number of pixels the pixel groups comprise.

5. The camera according to claim 1 wherein the pixels are arrayed in rows and columns.

6. The camera according to claim 5 wherein the super pixels are arrayed in rows and columns.

7. The camera according to claim 6 wherein the super pixels are QQVGA pixels each comprising sixteen pixels.

8. The camera according to claim 7 wherein the pixel groups comprise respectively one, three and twelve pixels.

9. The camera according to claim 8 wherein the pixels comprised in pixel groups comprising one and three pixels are located in a same column or row of pixels.

10. The camera according to claim 1 controllable to determine distances to features of a scene that the camera images.

11. The camera according to claim 10 wherein the camera is a time of flight 3D camera.

12. The camera according to claim 1 wherein to determine which pixel groups have an accumulation of photoelectrons that saturates the readout pixel, the controller:

determines a smallest pixel group comprised in the super pixel having an accumulation of photoelectrons that saturates the readout pixel; and

determines that accumulations of photoelectrons in pixel groups in the super pixel larger than the smallest pixel group having an accumulation of photoelectrons that saturates the readout pixel, saturates the readout pixel.

13. The camera according to claim 12 wherein the measure of the total number of photoelectrons in the super pixel is equal to a measure of the total accumulation of photoelectrons in pixel groups smaller than the smallest pixel group having an accumulation of photoelectrons that saturates the readout pixel, multiplied by a number equal to a number of pixels in the super pixel divided by a total number of pixels in the pixel groups smaller than the smallest pixel group having an accumulation of photoelectrons that saturates the readout pixel.

14. The camera according to claim 13 wherein the controller determines that a measure of the number of photoelectrons in the superpixel cannot be provided if the accumulation of photoelectrons in each of the pixel groups in the super pixel is indicated as saturating the readout pixel.

15. A method of measuring intensity of light incident on a photosensor comprising a plurality of light sensitive pixels that accumulate photoelectrons responsive to incident light, the method comprising:

tiling the photosensor into a plurality of super pixels, each partitioned into a plurality of pixel groups;

determining measures of amounts of photoelectrons accumulated by pixel groups to determine which pixel groups in a super pixel acquire an accumulation of photoelectrons responsive to the incident light that saturates a readout pixel and which pixel groups do not acquire an accumulation of photoelectrons that saturate the readout pixel; and

determining a measure of an accumulation of photoelectrons for the super pixel responsive to a function of the measurements of accumulations of photoelectrons determined not to saturate the readout pixel that has a form determined responsive to measurements of the number of photoelectrons in at least two of the pixel groups and is independent of the accumulations of photoelectrons determined to saturate the readout pixel.

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